

# IMPACT OF MODEL RESOLUTION ON THE WINTER NORTH ATLANTIC-EUROPEAN CLIMATE VARIABILITY AND PREDICTABILITY

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Impact of model resolution on climate variability and predictability is investigated. The relative contributions of atmosphere and ocean resolution are addressed.

EC-EARTHv3.0.1 / seasonal hindcasts initialized on November 1<sup>st</sup> over 1993-2009 (17 years); 10 members.  
Initial conditions: ERA-Interim (atmosphere) and GLORYS2v1 (ocean).

(Prodhomme et al. 2016, J.Clim 29:9141-9162)

Three different resolutions

SRes: T255-ORCA1L46

IRes: T255-ORCA025L75

HRes: T511-ORCA025L75

## 1. Impact on climatology

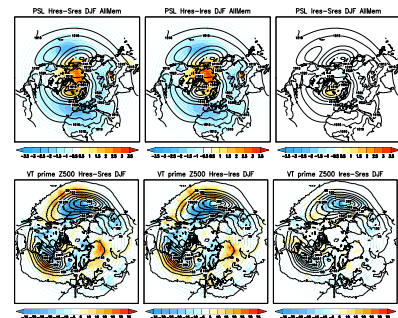


Figure 1: MSLP (top) and vT'500 (bottom) climatology in DJF of the seasonal hindcasts over 1993-2009, started on November 1<sup>st</sup> – i.e. 1-month lead time: contours for climatology of SRes; shading for HRes-SRes (left), IRes-IRes (middle), IRes-SRes (right).

- Increasing model resolution (HRes-SRes) has a significant impact on the winter MSLP climatology, particularly at mid-latitudes and over the polar cap, which is dominated by the increase in atmosphere resolution (HRes-IRes) [Fig. 1-top].

- The effect consists in a reduction of the meridional gradient of MSLP between middle and high latitudes that projects on a negative AO-like pattern.

- The impact of increasing atmosphere resolution (HRes-IRes) on the winter MSLP climatology is associated with a southward shift of the eddy-driven, baroclinic activity – here illustrated with changes in the transient-eddy heat flux at 500hPa (vT') [Fig. 1-bottom].

## 3. Understanding the changes in variability

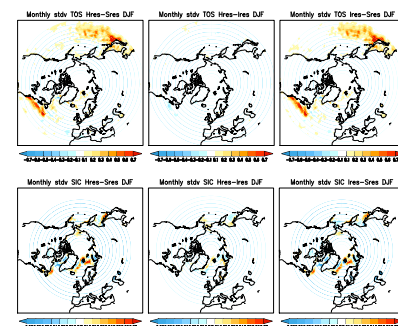


Figure 3: SST (top) and SIC (bottom) interannual standard deviation in DJF of the seasonal hindcasts over 1993-2009, started on November 1<sup>st</sup> – i.e. 1-month lead time: HRes-SRes (left), HRes-IRes (middle), IRes-SRes (right).

- The impact of increasing ocean resolution (IRes-SRes) on the winter MSLP [Fig. 2-top] and vT' [Fig. 2-bottom] variability is associated with statistically significant changes in SST variability along the Gulf Stream [Fig. 3-top] and SIC variability around the sea-ice edge of the Labrador Sea and the Greenland-Barents Seas [Fig. 3-bottom].

- These changes represent an increase in variability and are associated with a stronger air-sea coupling, namely higher correlation between SST and turbulent (sensible+latent) heat flux anomalies [not shown].

- The impact of increasing ocean resolution (IRes-SRes) on SST/SIC/THF variability dominates the effect of increasing model resolution (HRes-SRes) [Fig. 3].

## Key messages

- Increasing atmosphere resolution affects strongly the mean climate and weakly the variability of the North Atlantic-European winter.
- Increasing ocean resolution affects the variability but hardly the mean climate. Impact on variability is caused by jumping from non-eddy resolving to eddy-permitting resolution. This results in an increase of air-sea coupling.
- Increasing model resolution does not necessarily imply enhanced predictability. Enhanced potential predictability only occurs in regions where the increased atmospheric forcing signal compensates the increased noise.

## 2. Impact on variability

$\sigma_{\text{total}}$

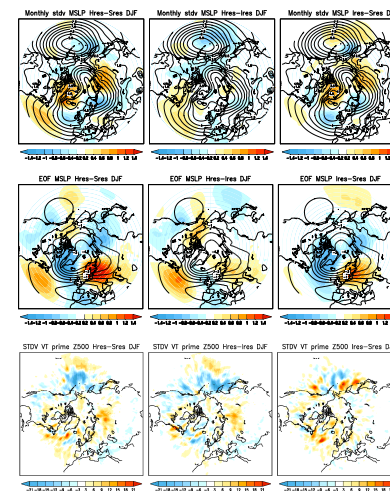


Figure 2: MSLP (top) and vT'500 (bottom) interannual standard deviation in DJF of the seasonal hindcasts over 1993-2009, started on November 1<sup>st</sup> – i.e. 1-month lead time; NAO pattern in DJF (middle row): contours for SRes; shading for HRes-SRes (left), HRes-IRes (middle), IRes-SRes (right).

- Increasing model resolution (HRes-SRes) has a significant impact on the winter MSLP variability, showing a longitudinal shift at subpolar latitudes and a local enhancement at mid-latitudes over the Euro-Atlantic sector, with the former dominated by the increase in ocean resolution (IRes-SRes) and the latter by the increase in atmosphere resolution (HRes-IRes) [Fig. 2-top].

- Both effects translate into changes in the spatial pattern of the leading mode of regional climate variability, namely the North Atlantic Oscillation (NAO). While increasing atmosphere resolution (HRes-IRes) mainly amplifies the anomaly in the western part of the basin, increasing ocean resolution (IRes-SRes) shifts the location of the northern centre of action – which has important climatic and environmental significance (see AGU monograph in 2003) [Fig. 2-middle].

- The impact of increasing model resolution (HRes-IRes) on the winter MSLP variability is split into more baroclinicity (atm. resolution, HRes-IRes) and more injection of wave activity to the storm-track (ocn. resolution, IRes-SRes) [Fig. 2-bottom].

## 4. Implications for predictability

$\sigma_{\text{ens-mean}}$

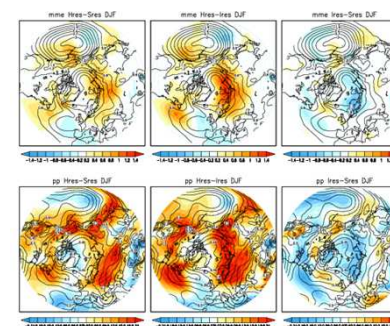


Figure 4: MSLP standard deviation of the ensemble-mean (top) and potential predictability (bottom) in DJF of the seasonal hindcasts over 1993-2009, started on November 1<sup>st</sup> – i.e. 1-month lead time: contours for SRes; shading for HRes-SRes (left), HRes-IRes (middle), IRes-SRes (right).

$$\text{potential predictability (pp)} = \sigma_{\text{ens-mean}} / \sigma_{\text{total}}$$

(Hawkins et al. 2011, ClimDyn 37:2495-2509)

- Increasing atmosphere resolution (HRes-IRes) leads to an enhanced potential predictability over the western North Atlantic and northern Eurasia, which mainly comes from an increased forced signal in those areas [Fig. 4-middle column].

- Increasing ocean resolution (IRes-SRes) leads to a reduction in potential predictability in those areas due to a decreased forced signal [Fig. 4-right column] and increased noise [Fig. 2-top,right].

- But increasing ocean resolution (IRes-SRes) also leads to an enhanced potential predictability along the North Atlantic storm-track due to an increased forced component [Fig. 4-right column] and reduced noise [Fig. 3-top,right].